SPACING THE ELLIPSE.

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I have frequently found it necessary in the course of my business, which is specially confined to the making and cutting of gear wheels, to cut the teeth of an elliptic gear. Although I have always used the greatest care and have had the advantage of experience and the best of tools, I have seldom succeeded in actually cutting such a gear to the combined satisfaction of myself and my customer, while, from a business point of view, nothing but a price that is almost prohibitory will make an order for such a gear in any way desirable.

The difficulty has been in the spacing of the curve so that the teeth could be evenly placed and give a smooth action. The usual method is to draw the curve and space it with the dividers, step by step, and, although the process is simple enough to describe, it is exceedingly clumsy, tedious, and inaccurate in operation.

Realizing that the only impediment to the general use of the elliptic gear for quick return motions and for other variations of speed, in positions where its simplicity and its positive action makes it unrivalled by any other mechanical movement, was the present expense of producing it and the poverty of the usual result, I undertook the construction of a special machine for the purpose. I had no difficulty in designing a machine that would keep the cutter accurately in the elliptic path, but it was only after a long search and many experiments that I found a device for spacing the elliptic outline that would serve that purpose even approximately.

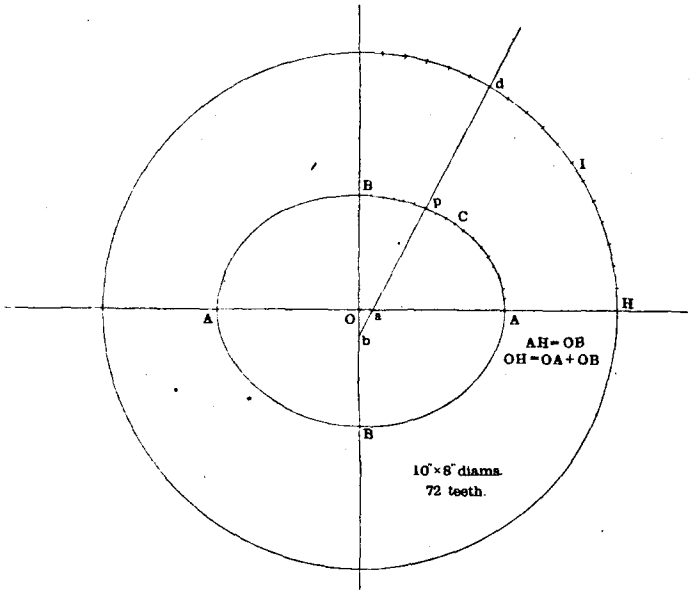
The result of my search was the device here described, and it can be easily applied with a degree of accuracy that is far beyond the requirements of actual practice.

In the figure, suppose the ellipse to be described on the principle of the common trammel, the two pins *a* and *b*

being confined to the two lines OA and OB, while the point p draws the curve.

Draw an index circle, I, from the centre, O, of the ellipse, and let its radius, OH, be equal to the sum of the radii, OA and OB, of the ellipse. Then, if the line, $b\ a\ p$, extended, accurately spaces the index circle at d, it will also space the ellipse with an accuracy that is practically perfect for cases that are in use for elliptic gears.

To show the accuracy of the device take a very common example. Given, an ellipse with a major diameter of ten



inches and a minor diameter of nine inches, with seventy-two teeth. This ellipse, used as a quick return motion, would give a ratio of slow stroke to quick return stroke of more than three to one, and when used for variation of speed, would give a variation of fastest speed to slowest speed of about six and one-half to one. It is, therefore, a practical example, elliptic gears being generally much more nearly circular.

For this example the errors in spacing, although theoretically present, are practically nothing. The chord of the

tooth space at the major apex *A* is ·41433 inch, while that at the minor apex *B* is ·41441 inch, giving an error of about one twelve-thousandth of an inch. The greatest error is on the quarter, at *C*, and not at the apices, but the difference between the greatest and the least tooth spaces is not over one two-thousandth of an inch.

If we take an extreme case we shall find a greater error. For diameters of twelve and six inches and seventy-two teeth, which would be wholly useless for practical purposes, the greatest error is still very small, not over one-seventieth of an inch, while the error between the apices is still practically nothing.

For the case shown in the figure, an ellipse having diameters of eight and ten inches and seventy-two teeth, the maximum error is one four-hundredth of an inch. This gear will give a ratio of greatest to least speed of sixteen to one, while as a quick return motion the ratio is more than five to one.

With the machine now being made I confidently expect to be able to cut elliptic gears quite as accurately as I can now cut circular gears, and at an expense that is but little greater. When the elliptic gear can be well and cheaply made, I see no reason why its use should not be increased ten-fold, for it is one of the neatest and most useful of mechanical devices.